Atmospheric centers of action in the Northern Hemisphere: Possible changes in the 21st century from CMIP6 model simulations

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An analysis of possible changes of the atmospheric centers of action (ACA) in the Northern Hemisphere under global warming was carried out. We used the results of simulations with climate models of the CMIP6 ensemble with the SSP5-8.5 scenario for the 21st century.

The areas corresponding to each of the analyzed ACAs were identified similar to (Mokhov et al., 2020). Within the area corresponding to ACA, the mean sea level pressure Pc was determined with increased or decreased pressure for anticyclonic or cyclonic conditions, respectively (see also (Mokhov et al., 2018; Mokhov et al., 2021). The ACA intensity was characterized both by the pressure at sea level in the ACA region Pc and by the corresponding pressure drop Ic relative to the mean hemispheric pressure P_H at sea level. We also analyzed the relative changes in the ACA intensity Ic = Ic/ δ Ic - when normalizing Ic to the corresponding standard deviations (SD) δIc.

Table 1. Intensity Ic [hPa] of ACAs in the Northern Hemisphere for winter (a) and summer (b) from simulations with selected CMIP6 ensemble of climate models and by ERA5 reanalysis data for the base period 1981-2005. The standard deviations (SD) of the ACA intensity are given in parentheses.

(a)

ACA Seasonal Mean Intensity (hPa)	Winter (DJF)	
	Reanalysis	CMIP6 models
Azores High	4.8 (±1.6)	5.0 (±2.0)
Siberian High	10.5 (±1.1)	10.2 (±1.5)
North American High	3.0 (±1.0)	3.2 (±1.3)
Aleutian Low	-9.6 (±2.7)	-9.9 (±3.5)
Icelandic Low	-10.9 (±2.8)	-11.4 (±3.1)

(b)

ACA Seasonal Mean Intensity (hPa)	Summer (JJA)	
	Reanalysis	CMIP6 models
Azores High	8.2 (±0.6)	8.4 (±0.6)
Hawaiian High	7.6 (±0.6)	8.0 (±0.7)
Asian Low	-8.4 (±0.3)	-8.7 (±0.5)

The quality of the ACAs simulations was evaluated in comparison with ERA5 reanalysis data (https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5) for the base period 1981-2005. As a result of a comparative analysis with reanalysis data, 11 models of the CMIP6 ensemble were selected, which best reproduce the ACAs for the base period in comparison with the reanalysis data. Table 1 presents intensity Ic of key centers of atmospheric action in the Northern Hemisphere for winter (a) and summer (b) from simulations with selected CMIP6 ensemble of climate models and by ERA5 reanalysis data for the base period 1981-2005. The standard deviations (SD) of the ACA intensity are given in parentheses.

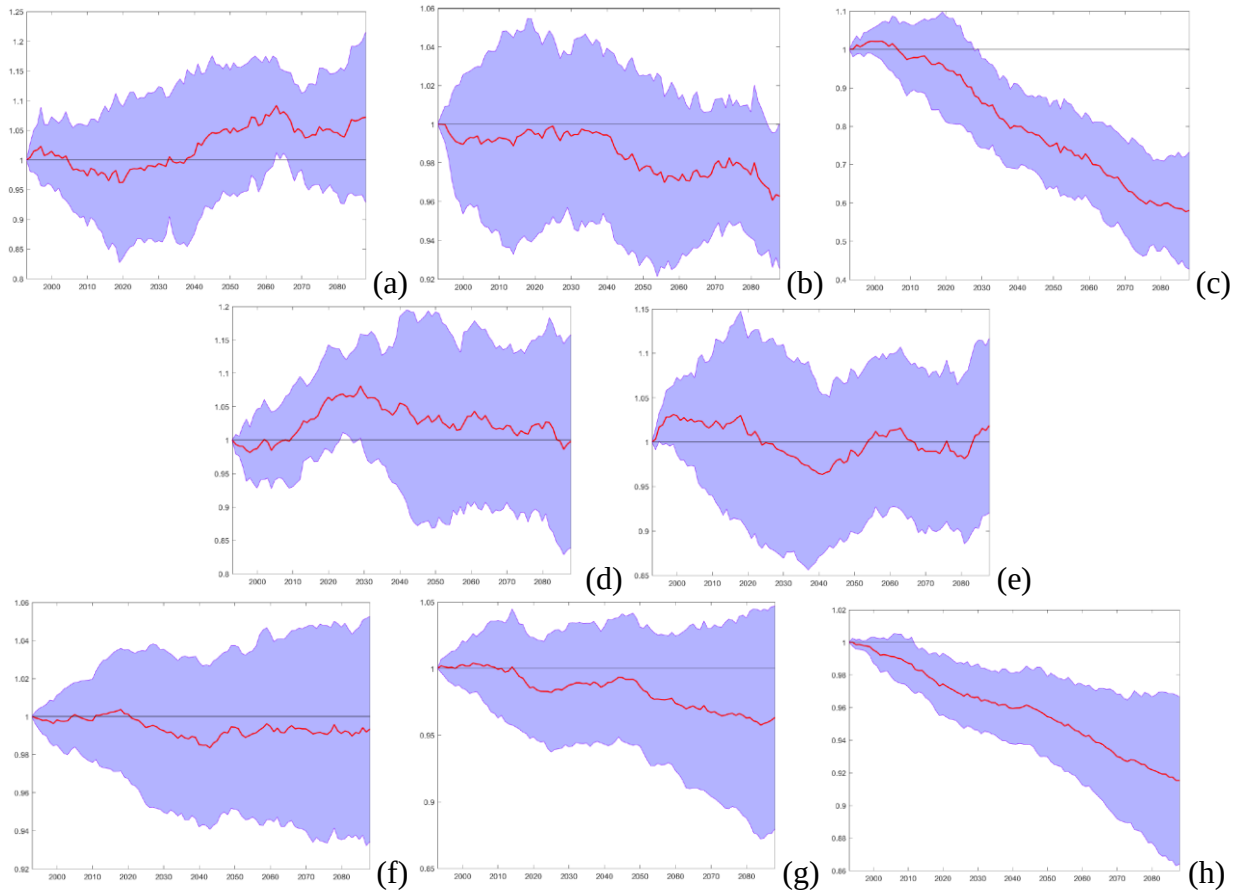

Figure 1. Changes in ACA intensity (normalized to SD for the base period 1981-2005) in the Northern Hemisphere according to simulations with a selected ensemble of CMIP6 models under the SSP5-8.5 scenario. Here: (a) Azores High, (b) Siberian High, (c) North American High, (d) Aleutian Low, (e) Icelandic Low - winter ACA; (f) Azores high, (g) Hawaiian High, (h) Asian Low – summer ACA. SD ranges relative to 30-year moving averages (red curves) are shaded.

Possible changes in the ACA intensity in the Northern Hemisphere from simulations with a selected ensemble of CMIP6 models under the SSP5-8.5 scenario for the 21st century are presented on Fig. 1. The most consistent estimates based on simulations with the ensemble of the CMIP6 models were obtained for the weakening tendencies of the winter North American High and the summer Asian Low. For the Siberian High in winter, the weakening trend was found less significant.

This work was supported be the Russian Science Foundation (project 19-17-00240).

References

Mokhov I.I., Chernokulsky A.V., Osipov A.M. Changes in the characteristics of atmospheric centers of action. In: Intense Atmospheric Vortices and Their Dynamics. Ed. By I.I. Mokhov, M.V. Kurgansky, O.G. Chkhetiani. Moscow, GEOS, 2018, 398—403. (In Russian)

Mokhov I.I., Chernokulsky A.V., Osipov A.M. Atmospheric centers of action in the Northern and Southern Hemispheres: Features and variability. Rus. Meteorol. Hydrol., 2020, V. 45, No. 10, pp. 749–761.

Mokhov I.I., Chernokulsky A.V., Osipov A.M. Atmospheric centers of action in the Northern and Southern Hemispheres: Tendencies of change in the 21st century from model simulations. Research Activities in Earth System Modelling. 2021. Rep. 51. WCRP Report No.4/2021. WMO, Geneva, S. 7. P. 11-12.